UDC 621.9.015:621.7.015

JIS

This standard was revised in 2, 1994

JAPANESE INDUSTRIAL STANDARD

Definitions and Designation of Surface Roughness

JIS B 0601 -1982

Translated and Published

by

Japanese Standards Association

Printed in Japan

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In the event of any doubt arising,
the original Standard in Japanese is to be final authority.

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Definitions and Designation of Surface Roughness

B 0601-1982
(Reaffirmed: 1992)

1. Scope

This Japanese Industrial Standard specifies the definitions and designation of the center-line mean roughness (R_a), maximum height (R_{max}) and ten-point mean roughness (R_z) expressing the surface roughness of industrial products.

Informative Reference

Although three kinds of designations given above are specified in this standard, it is preferable to use the designation by the center-line mean roughness in our country, because the applicational frequency of designation by the center-line mean roughness is high internationally.

2. Definitions

For the purpose of this standard, the following principal definitions apply:

(1) surface roughness Each arithmetic mean value of R_a, R_{max} or R_z at several parts sampled randomly from the surface of an object, hereinafter referred to as the "objective surface".

Remarks 1. Generally in an objective surface, surface roughnesses on individual positions are not uniform, and usually present considerably large dispersion. Therefore, in assessing the surface roughness of the objective surface, it is necessary to determine the measuring positions and numbers thereof so that the population mean can be assumed effectively.

2. According to the objects of measurement, an assessed value at one point on the objective surface may represent the surface roughness of the entire surface.

(2) profile A contour appears on a cut end, when a surface to be measured has been cut with a plane which is perpendicular to that surface.

Remark: In this cutting, unless otherwise specified, it shall be cut in a direction so that the surface roughness appears in the maximum magnitude. For example, in a surface to be measured having lay, it shall be cut in perpendicular to that direction.

(3) reference length of profile A length of a part sampled from the profile in a fixed length, hereinafter referred to as the "reference length".

Applicable Standards: See page 12.

(4) roughness curve and cut-off value A curve which has been cut off any longer surface waviness component than a prescribed wave length from the profile is defined as the roughness curve, and this prescribed wave length is defined as the cut-off value.

(5) mean line of profile or roughness curve A straight line or a curve having a geometrical feature of a surface to be measured within a sampled part of the profile or roughness curve, as well as so established that the sum of the squares of the deviations of the profile or roughness curve from that line is minimum.

(6) center-line of roughness curve A straight line which has been drawn in parallel with the mean line of the roughness curve so that the sums of the areas contained between it and the roughness curve which lie on each side of it are equal, hereinafter referred to as the "center-line".

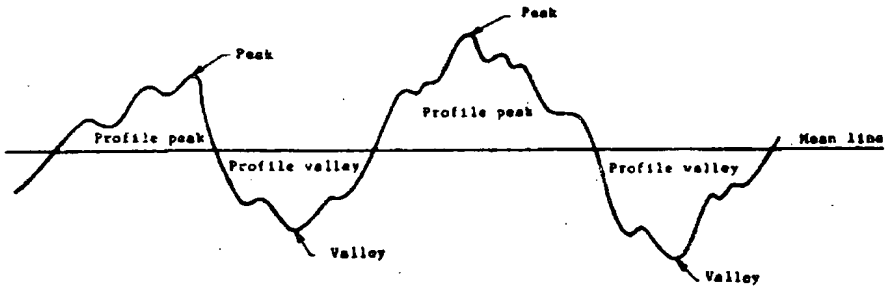
(7) profile peak When a profile has been cut with the mean line, the protruding part of a real surface above the mean line, within the profile connecting two adjacent points of the intersection thereof (see Fig. 1).

(8) profile valley When a profile has been cut with the mean line, the sunken parts of a real surface below the mean line, within the profile connecting two adjacent points of the intersection thereof (see Fig. 1).

(9) peak A point of the highest altitude in the profile peak (see Fig. 1).

(10) valley A point of the lowest altitude in a profile valley (see Fig. 1).

Fig. 1. Profile Peaks, Profile Valleys, Peaks and Valleys



3. Definitions and Designation

3.1 Definition of Center-line Mean Roughness (R_a)

3.1.1 Determination of Center-line Mean Roughness The center-line mean roughness, when the roughness curve has been expressed by $y=f(x)$, shall be a value, being expressed in micrometer (μm), that is obtained from the following formula, extracting a part of measuring length l in the direction of its center-line from the roughness curve, and taking the center-line of this extracted part as X-axis and the direction of vertical magnification as Y-axis.

$$R_a=\frac{1}{l}\int_0^l |f(x)|dx$$

3.1.2 Cut-off Value of Roughness Curve The cut-off value of the roughness curve, when a high-pass filter of -12 dB/oct in attenuation factor has been used in obtaining the roughness curve, shall be the wave length corresponding to the frequency attaining a gain of 75 %, hereinafter referred to as the "cut-off value".

3.1.3 Cut-off Values The cut-off values shall generally be the following six kinds:

0.08, 0.25, 0.8, 2.5, 8, 25 Unit: mm

3.1.4 Standard Values of Cut-off Values The standard values of the cut-off value, unless otherwise specified, shall be in accordance with the divisions in Table 1.

Table 1. Standard Values of Cut-off Value in Determining Center-line Mean Roughness

Range of center-line mean roughness		Cut-off value
Exceeding	Max.	mm
	12.5 μm R_a	0.8
12.5 μm R_a	100 μm R_a	2.5

Remark: Center-line mean roughness shall be determined by firstly designating the cut-off values. In carrying out the designation or instruction of the surface roughness, as it is inconvenient to designate that on all such occasions, unless otherwise required to specify, values of this table shall be used.

3.1.5 Measuring Length The measuring length shall generally be a value of three times or more the cut-off value.

3.2 Indication of Center-Line Mean Roughness(R_a)

3.2.1 Designation of Center-Line Mean Roughness The designation of the center-line mean roughness shall be as follows:

Center-line mean roughness _____ μm Cut-off value _____ mm Measuring length _____ mm

or

_____ μm R_a λ_c _____ mm l _____ mm

Remarks 1. In the case where the value of the center-line mean roughness obtained by using the standard value of the cut-off value given in Table 1 is in the range shown in Table 1, the designation of the cut-off value may be omitted.

2. In the case where the measuring length is three times or more the cut-off value, the designation of the measuring length may be omitted.

3.2.2 Preferred Number Series of Center-Line Mean Roughness When the surface roughness is designated by the center-line mean roughness, unless otherwise required, the preferred number series of Table 2 shall be used.

Table 2. Preferred Number Series of Center-Line Mean Roughness

0.013	0.4	12.5
0.025	0.8	25
0.05	1.6	50
0.1	3.2	100
0.2	6.3	-

3.2.3 Maximum Value Designation for Center-Line Mean Roughness In the case where the surface roughness is designated by the permissible maximum value for the center-line mean roughness, it shall be represented by the numerical value selected from the preferred number series of Table 2, suffixing a.

Remarks 1. The permissible maximum value mentioned here shall be an arithmetic mean value of R_a on several points randomly extracted from the indicated surface, but shall not be the maximum value of individual R_a value.

2. The maximum value designation of the center-line mean roughness for example 6.3 a means $0\,\mu m\,R_a \leq 6.3\,a \leq 6.3\,\mu m\,R_a$.

3. For the cut-off value in the case of the maximum value designation of the center-line mean roughness, a value corresponding to the maximum value in Table 1 shall generally be used. When any cut-off value other than this value is to be used, this value shall be appended.

3.2.4 Sectional Designation for Center-Line Mean Roughness If it is required to designate a center-line mean roughness in certain section, numerical values corresponding to the upper limit (that of the larger designation value) and a lower limit (that of the smaller designation value) shall be stated additionally by selecting from Table 2.

Example 1: In the Case where Standard Values of Cut-off Values for Upper Limit and Lower Limit (Table 1) Are Equal: A sectional designation when the upper limit of 6.3 $\mu m R_a$ and the lower limit of 1.6 $\mu m R_a$ shall be designated as (6.3 to 1.6)a. In this case, 0.8 mm shall be used for the cut-off value.

Example 2: In the Case where Standard Values of Cut-off Values for Upper Limit and Lower Limit (Table 1) Are Different: A sectional designation when the upper limit of 25 $\mu m R_a$ and the lower limit of 6.3 $\mu m R_a$ shall be designated as (25 to 6.3)a. In this case, it means that a center-line mean roughness measured by a cut-off value of 2.5 mm is 25 $\mu m R_a$ or under, and that a center-line mean roughness measured by a cut-off value of 0.8 mm is 6.3 $\mu m R_a$ or over.

Remarks 1. In the case where it is required to equalize the cut-off values corresponding to the upper and the lower limits, or in the case where cut-off values other than standard values of Table 1 is to be used, the cut-off value shall be appended. In the case of Example 2, when the cut-off value corresponding to the upper and the lower limits is taken as 2.5 mm, it shall be designated as (25 to 6.3)a λ_c 2.5 mm.

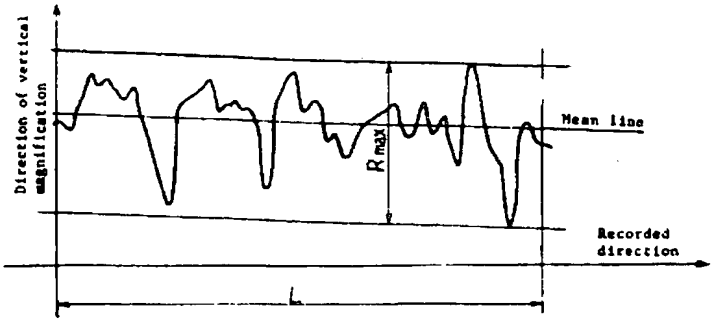
2. Center-line mean roughness of the upper and the lower limits mentioned here shall be the arithmetic mean values of R_a at several points sampled randomly from the designated surface, but shall not be the maximum value of individual R_a values.

3.3 Definition of Maximum Height (R_{max})

3.3.1 Determination of Maximum Height The maximum height, when a sampled portion has been interposed between the two parallel straight lines with a mean line of which length corresponds to the reference length that has been sampled from the profile, hereinafter, referred to as the "sampled portion", shall be the value, expressed in micrometer (μm) measuring the spacing of these two straight lines in the direction of vertical magnification of the profile.

The example of the determination of the maximum height is shown in Fig. 2.

Fig. 2. Example of Determination of the Maximum Height



L : reference length

R_{max} : maximum height of the sampled portion corresponding to the reference length l.

Remarks 1. In the case where the surface to be measured is a curved surface, the maximum height shall be obtained along the curve which is anticipated to appear on a cut end.

2. In the determination of the maximum height, a length corresponding to the reference length shall be sampled from the part which is free from extraordinary high peak and deep valley considered as flaws.

3.3.2 Reference Length In the determination of the maximum height, reference lengths shall generally be the following six kinds.

0.08, 0.25, 0.8, 2.5, 8, 25 Unit: mm

3.3.3 Standard Values for Reference Lengths The standard values for reference lengths, unless otherwise required to specify, shall conform to the division of Table 3.

Table 3. Standard Values for Reference Lengths in Determination of Maximum Height

Range of maximum height		Reference length mm
Exceeding	Max.	
—	0.8 μm R_{max}	0.25
0.8 μm R_{max}	6.3 μm R_{max}	0.8
6.3 μm R_{max}	25 μm R_{max}	2.5
25 μm R_{max}	100 μm R_{max}	8
100 μm	400 μm R_{max}	25

Remark: The maximum height shall be determined upon designation of the reference length at first, however, in indicating and designating the surface roughness, because it is inconvenient to designate that on all such occasions, unless otherwise required to designate, values given in this table shall be used.

3.4 Indication of Maximum Height (R_{max})

3.4.1 Designation of Maximum Height The maximum height shall be designated as follows:

Maximum height _____ μm Reference length _____ mm

or

_____ μm R_{max} *l*. _____ mm

Remark: In the case where the maximum-height value which has been obtained using the standard value of the reference length given in Table 3 lies within the range given in Table 3, the designation of the reference length may be omitted.

3.4.2 Preferred Number Series of Maximum Height In designating the surface roughness by the maximum height, unless otherwise specified, the preferred number series of Table 4 shall be used.

Table 4. Preferred Number Series of Maximum Heights

0.05	0.8	12.5	200
0.1	1.6	25	400
0.2	3.2	50	—
0.4	6.3	100	—

3.4.3 Maximum-value Designation for Maximum Height In designating the surface roughness by the permissible maximum value for the maximum height, it shall be expressed by suffixing S after the numerical value selected from the series in Table 4.

Remarks 1. The permissible maximum value mentioned here shall be an arithmetic mean value of R_{max} at several places randomly sampled from the designated surface, but shall not be the maximum value of individual R_{max} .

2. A maximum value designation of the maximum height 3.2 S, for instance, means $0\ \mu m\ R_{max} \leq 3.2\ S \leq 3.2\ \mu m\ R_{max}$.

3. For a reference length in the case of the maximum value designation for the maximum height, a value corresponding to the maximum value in Table 3 shall generally be used. When a reference length other than this value is used, the value shall be appended.

3.4.4 Sectional Designation for Maximum Height If it is required to designate the maximum height in a certain section, numerical values corresponding to the upper limit (the larger value of the designated value) and the lower limit (the smaller value of the designated value) of that section shall be selected from Table 4 and be stated together.

Example 1: If Standard Values for Reference Lengths of Upper and Lower Limits (Table 3) Are Equal: The sectional designation for the upper limit of 3.2 μm R_{max} and lower limit of 0.8 μm R_{max} shall be designated as (3.2 to 0.8)S. In this case, 0.8 mm shall be used for the reference length.

Example 2: If Standard Values for Reference Lengths of Upper and Lower Limits (Table 3) Are Different: The sectional designation for the upper limit of 3.2 μm R_{max} and lower limit of 0.4 μm R_{max} shall be designated as (3.2 to 0.4)S. In this case, it means that the maximum height using a reference length of 0.8 mm is 3.2 μm R_{max} or under, and that the maximum height using a reference length of 0.25 mm is 0.4 μm R_{max} or over.

Remarks 1. In the case where reference lengths corresponding to the upper and lower limits are required to be equal, or where any reference length other than the standard value of Table 3 is to be used, the reference length shall be stated together. In Example 2: when the reference length corresponding to the upper and lower limits is selected as 0.8 mm, it shall be designated as (3.2 to 0.4)S *L* 0.8 mm.

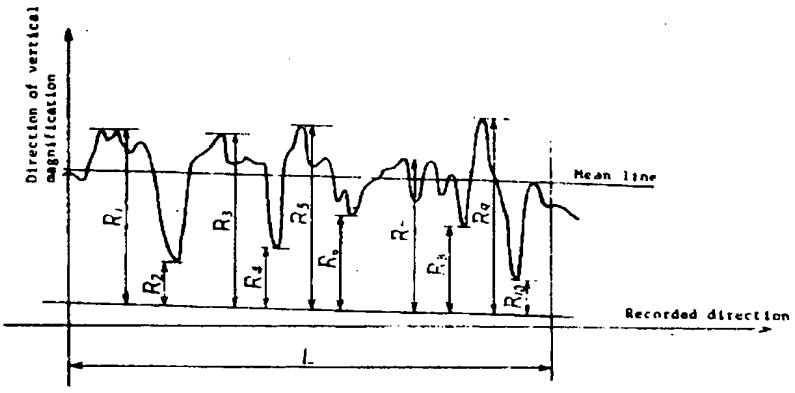
2. The maximum height of upper and lower limits mentioned here shall be an arithmetic mean value of R_{max} at several places which have been sampled randomly from the designated surface, but shall not be the maximum value of individual R_{max}.

3.5 Definition of Ten-Point Mean Roughness (R_z)

3.5.1 Determination of Ten-Point Mean Roughness The ten-point mean roughness shall be the value of difference, being expressed in micrometer (μm), between the mean value of altitudes of peaks from the highest to the 5th, measured in the direction of vertical magnification from a straight line that is parallel to the mean line and that does not intersect the profile, and the mean value of altitudes of valleys from the deepest to the 5th, within a sampled portion, of which length corresponds to the reference length, from the profile.

An example of determination of the ten-point mean roughness is shown in Fig. 3.

Fig. 3. Determination of Ten-Point Mean Roughness



L : reference length

R_1, R_3, R_5, R_7, R_9 : altitudes of peaks from the highest to the 5th for the sampled portion corresponding to the reference length L

$R_2, R_4, R_6, R_8, R_{10}$: altitudes of valleys from the deepest to the 5th for the sampled portion corresponding to the reference length L

$$R_z = \frac{(R_1 + R_3 + R_5 + R_7 + R_9) - (R_2 + R_4 + R_6 + R_8 + R_{10})}{5}$$

Remarks 1. In the definition of the ten-point mean roughness, it requires a certain extent of time from measurement to calculation, because the ten-point mean roughness is to be determined from the difference, obtaining respective mean values by measuring five altitude values, from the highest (deepest) to the 5th, on the sampled portion of the profile. In a profile obtained from an actual processing surface, generally no significant difference is recognized between the value which has been indicated by the difference, obtaining a median in lieu of a mean value, and the ten-point mean roughness value.

Furthermore, it is clarified that the time required for measurement and calculation can be reduced remarkably.

2. In the case where the surface to be measured is a curved surface, the ten-point mean roughness shall be obtained along a curve expected to appear on a cut end.

3.5.2 Reference Length The reference length, in the determination of the ten-point mean roughness, shall generally be the following six kinds:

0.08, 0.25, 0.8, 2.5, 8, 25 Unit: mm

3.5.3 Standard Values of Reference Length The standard values of the reference lengths, unless otherwise required to designate, shall conform to the division of Table 5.

Table 5. Standard Values of Reference Lengths in Determining Ten-Point Mean Roughness

Range of ten-point mean roughness		Reference length mm
Exceeding	Max.	
—	0.8 μm R_z	0.25
0.8 μm R_z	6.3 μm R_z	0.8
6.3 μm R_z	25 μm R_z	2.5
25 μm R_z	100 μm R_z	8
100 μm R_z	400 μm R_z	25

Remark: The ten-point mean roughness shall be determined on designating the reference length at first. In the case where the indication and designation of the surface roughness are to be carried out, because it is inconvenient to designate this on all such occasions, unless otherwise required to designate, the value of this Table shall be used.

3.6 Indication of Ten-Point Mean Roughness (R_z)

3.6.1 Designation of Ten Point Mean Roughness The designation of the ten-point mean roughness shall be as the following:

Ten-point mean roughness _____ μm Reference length _____ mm

or

_____ μm R_z L _____ mm

3.6.2 Preferred Number Series of Ten-Point Mean Roughness In the designation of the surface roughness by the ten-point mean roughness, unless otherwise required, the preferred number series of Table 6 shall be used.

Table 6. Preferred Number Series of Ten-Point Mean Roughness

0.05	0.8	12.5	200
0.1	1.6	25	400
0.2	3.2	50	-
0.4	6.3	100	-

3.6.3 Maximum Value Designation for Ten-Point Mean Roughness In designating the surface roughness by the permissible maximum value for the ten-point mean roughness, it shall be indicated by suffixing Z after the numerical value selected from the preferred number series of Table 6.

Remarks 1. The permissible maximum value mentioned here shall be an arithmetic mean value of R_z at several places randomly sampled from a designated surface, and shall not be the individual maximum value.

2. The maximum value designation of the ten-point mean roughness, for example, 6.3 Z means $0\ \mu m R_z \leqq 6.3Z \leqq 6.3\ \mu m R_z$.

3. For the reference length, in the case of the maximum value designation of the ten-point mean roughness, a value corresponding to the maximum value in Table 5 shall generally be used. When any reference length other than this value is to be used, the value shall be appended.

3.6.4 Sectional Designation for Ten-Point Mean Roughness When it is required to designate the ten-point mean roughness in a certain section, numerical values corresponding to the upper limit (the larger value of the designated values) and the lower limit (the smaller value of the designated values) shall be selected from Table 6 and be stated together.

Example 1: If Standard Values for Reference Length of Upper Limit and Lower Limit (Table 5) Are Equal: The sectional designation for the upper limit 6.3 $\mu m R_z$ and lower limit 1.6 $\mu m R_z$ shall be indicated as (6.3 to 1.6)Z. In this case, 0.8 mm shall be used for the reference length.

Example 2: If Standard Values for Reference Length of Upper Limit and Lower Limit (Table 5) Are Different: The sectional designation for the upper limit 25 $\mu m R_z$ and the lower limit 6.3 $\mu m R_z$ shall be indicated as (25 to 6.3)Z. In this case, it means that the ten-point mean roughness measured in the reference length of 2.5 mm is 25 $\mu m R_z$ or under, and that the ten-point mean roughness measured in the reference length of 0.8 mm is 6.3 $\mu m R_z$ or over.

Remarks 1. If it is required to equalize the reference lengths corresponding to the upper and lower limits or if any reference length other than the standard value of Table 5, the reference length shall be stated together. In the case of Example 2, if the reference length corresponding to the upper and lower limit is to be taken as 2.5 mm, it shall be designated as (25 to 6.3)Z, L 2.5 mm.

2. The ten-point mean roughness of the upper and lower limits mentioned here shall be an arithmetic mean value of R_z on several places randomly sampled from the designated surface, and shall not be the individual maximum value.

Applicable Standards:

JIS B 0031-Method of Indicating Surface Texture on Drawings

JIS B 0610-Waviness

JIS B 0651-Instruments for the Measurement of Surface Roughness by the Stylus Method

JIS B 0652-Instruments for the Measurement of Surface Roughness by the Interferometric Method

ISO R 468-Surface roughness

B 0601-1982
Edition 15

Japanese Text

Established by Minister of International Trade and Industry

Date of Establishment: 1952-05-21
Date of Revision: 1982-06-15
Date of Reaffirmation: 1992-02-01
Date of Public Notice in Official Gazette: 1992-10-26

Investigated by: Japanese Industrial Standards Committee

Divisional Council on Machine Element

Technical Committee on Surface Roughness

This English translation is published by:
Japanese Standards Association
1-24, Akasaka 4, Minato-ku,
Tokyo 107 Japan

Printed in Tokyo by
Hohbunsha Co., Ltd.